STOCK MAINTENANCE BY TELEPHONE—ONE STEP TOWARDS INTEGRATED MANUFACTURING CONTROL IN A MULTI-SHOP MANUFACTURING COMPLEX

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INTRODUCTION

The Kearny Works of the Western Electric Company employs some 14,600 people, who are involved in the manufacture of a wide variety of electrical equipment, and their electrical and mechanical components. Thirty production shops operate more or less autonomously to manufacture some $200,000,000 of product each year. These shops obtain parts, components and raw material from outside suppliers, and from other shops and Works in the Company. They sell to other shops and Works, Bell System Companies, and the Government. Stock investment in independent storerooms associated with the various shops is considerable, and its effective control is always of strong concern to management. It was recognized early that introduction of Operations Research and Computer methods would be of considerable benefit.

The manual tabulating system of stock control generally in use was developed over many years of operation and is based on product-shop concepts. Each store stocks items required by its associated shop to make its product. Where items are common to more than one shop the heaviest user becomes the stocking store. This policy gives assurance that the most qualified judgment is applied to forecasting future requirements. However, it makes system analysis difficult, since store operating policies and procedures differ significantly from one ordering and production-servicing organization to another. In addition, a wide variety of types of stock items, differing in demand patterns, procurement intervals, value, suppliers, and type of usage, are usually present in a store or group of associated stores.

This paper describes the completed first stage of a generalized Electronic Data Processing system designed for application to stock maintenance in the various Works storerooms. The installed system incorporates DATA-PHONE service for transmission of store transactions to a Data Center and processing of these transactions by a 7080 computer for stock status evaluation. Discussion centers on design of the system from two major viewpoints—

(1) as the initial stage in constructing and implementing an effective Operations Research model for inventory-production control;

(2) as one phase in the construction of a wholly integrated manufacturing control system.

OPERATIONS RESEARCH AND SYSTEMS ENGINEERING

The practical difficulties touched upon above had much to do with how an Operations Research Group was led to develop the system described in this paper. Such development is more properly characterized as manufacturing systems engineering. We want to make it clear from the outset that we are aware of this. In fact the question of how it came about is a significant aspect of this paper.

An Operations Research Group has been operating at the Headquarters location of Western Electric since 1954. However, during the past 2–3 years, groups have been organized independently at various manufacturing locations to exploit cost reduction possibilities of the new field in local in-plant operations. When the Kearny group was formed early in 1960, the objective of tangible cost reduction and the assignment of a functional responsibility for implementation of OR techniques enabled us to reassess commonly accepted concepts in the field of OR operation: (1) that OR organizations have little real need for a computer, and in fact, for most effective operation should operate independently of a computer, (2) that OR is primarily a consulting function in a strictly mathematical area. These two beliefs probably derive from the usual method of operation of a staff organization or an independent consulting firm, where OR is brought in on request from a local organization, which still bears the basic responsibility for methods improvement and cost reduction. The two concepts can be accepted to some extent as general truisms on this basis. However, they put OR as a purely local organization in a rather unenviable position. Consider first the ramifications if the first belief was accepted as our operating policy for the local OR group here at Kearny.

It was clear that the logical place to put OR to work was in the production and inventory control area. Theory was well developed, management was aware of the potentialities, and the processes concerned were of the large scale, continuous nature which could be expected to generate significant cost reduction. However, with largely manual systems operating in the decision-making areas of inventory and production control, certain significant phases of an OR project could not satisfactorily be carried out. The systems analysis and data collection required to define a problem and justify the expenditures needed for a solution in any worthwhile area was a massive project in itself. Even if the problem could be satisfactorily defined, a model constructed, a solution derived and adequately tested, a system to implement the solution with effective control would be required. The initial conclusion drawn was that organization of the OR function according to accepted practice would be too limited to be effective. A group working strictly within the defined OR function would necessarily be restricted to one-shot projects and consultant work until the Computer Methods Development organization had constructed a workable framework for initiating an OR project in inventory and production control. This type of operation was not likely to meet management objectives in any reasonable period of time.

The second belief, which would require us to concern ourselves primarily with mathematical formulation, would have been even more impractical. The major difficulty in applying OR locally lay in the definition of a problem and the implementation of a solution, not in the mathematical formulation necessary to construct a model and derive a solution. Much basic research has been done in the area of production and inventory control. The literature is replete with mathematical models and theory. The challenge was to put the theory into practice. Restricting the OR function to mathematical formulation would serve merely to increase by another inch, the mile-long gap between theory and practice.

What we did of course is clear. We ignored the second preconception, and redefined the OR project to render the first invalid. The first step of an OR project is frequently described as "define the problem." Selecting general inventory and production control as our project, we rationalized this first step to include construction of a data collection and processing system. This would enable us to analyze the current methods and policies of operation, and secondly, to collect data for model construction and test. At the same time, conversion from manual to electronic data processing would generate tangible savings in system operation for the short term. Before describing the operation of the system, some general remarks on what we consider to be its most significant feature—flexibility.

EVOLUTION VS. REVOLUTION

As indicated earlier, the Kearny Works comprises some 30 different manufacturing shops. Each operates almost autonomously, making different products, under differing conditions, with different machines and processes. The functions of supporting organizations (accounting, engineering, wage incentives, purchasing, etc.) generally overlap two or more of these different shops. The shops themselves usually are linked to each other in one way or another.

In the introduction of EDP to Kearny inventory and production control, an "evolutionary" approach has been taken. The Works manufacturing process can be described very generally as composed of three stages: (1) equipment ordering and analysis, (2) stock control and (3) shop production. Orders placed by customers for equipment, when exploded into required assemblies and components, determine the loads to be placed on each shop. Component orders placed on the Works manufacturing shops are either filled from stock or made to order by that shop. Computer Methods Development was directing its effort to completing the ordering stage, covering all shops and products before proceeding to the next phase. It should be noted that decision-making processes were not involved in this area. Computer systems were complex, but did not require incorporation of decision-making controls or criteria. The EDP system we engaged to develop similarly was designed to cover one stage, stock control, in breadth, before extending in depth to the third stage, that of production control.

This approach is in contrast to that frequently taken, which covers one shop in depth for all three stages at one time, thus revolutionizing the operation of the shop in a relatively short period. The evolutionary approach was required at Kearny because of the number and variety of shops to be covered. However, it also offered significant advantages in the cushioned impact it had on the shops and in the facility of system analysis and design. With this approach it was essential that in designing a data collection and processing system we should be able to:

- — easily adjust to operational differences between stores and shops;
- — install the system quickly in each store and with minimum change in normal operations;
- — provide for easy linkage to the ordering stage under development by the Computer System group;
- — provide for extension into the production control stage;
- — provide for expansion to the subsidiary functions of accounting, engineering, purchasing, warehousing, etc.

From an OR standpoint, it had to be borne in mind that the system we were designing was concerned primarily with the definition of existing decision-making processes and was to provide the data for model construction and test. It then had to provide facilities for control and implementation of the solution. In short, the system had to be extremely flexible.

This need for great flexibility was our primary reason for selection of DATA-PHONE service and for organization of a central data receiving area for the Works.

STOCK CONTROL BY DATA-PHONE SERVICE AND COMPUTER

The Kearny Works includes five satellite manufacturing locations in addition to the tract at Kearny, as indicated in figure 1. In all there are some thirty separate storerooms, each associated with certain manufacturing shops. Basic bookkeeping methods are substantially the same in all stores. Records are kept, manually or by Electric Accounting Machinery, of material movement in and out, replenishment orders and receivals, stock transfers balancing entries, and so on. However, the factors which must be investigated in order to effectively improve control of investment differ considerably from store to store. The new DATA-

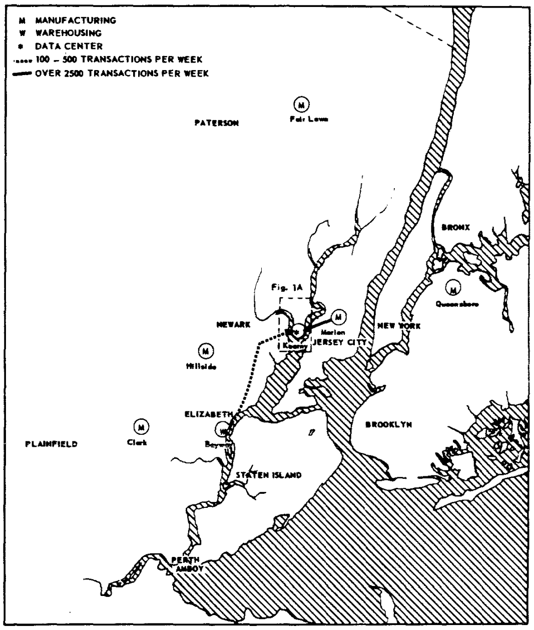

Figure 1. Kearny Works and Satellite Locations—(Showing Present Inter-Plant Network).

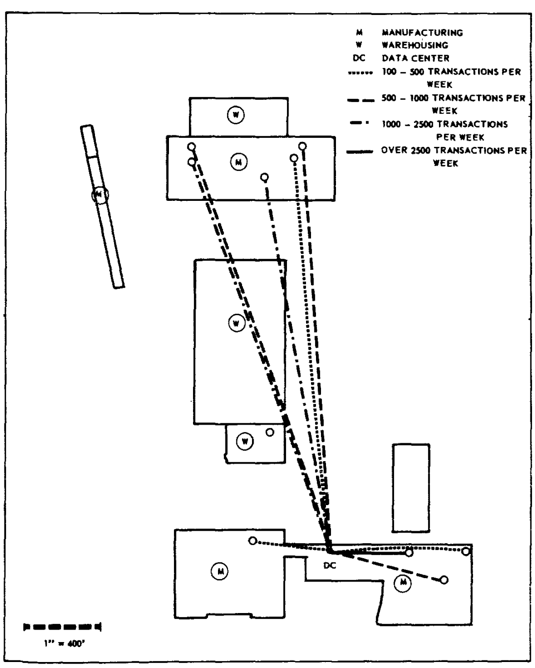

Figure 1A. Kearny Works—Main Plant Internal DATA-PHONE Service Network.

PHONE-Computer system is designed to provide more effective bookkeeping while facilitating comprehensive study of storeroom operation. Although the major benefits of the system are to be realized over a period of several years as a result of such study, considerable savings are being achieved in the initial stages simply by providing management with more effective control information, using EDP methods and some fundamental OR techniques. The system has two component phases:

Data Collection

A Data Center is located in the main building of the Kearny tract proper, convenient to the computer. The Center currently consists of three receiving stations (DATA-PHONE receiver, translator and specially equipped keypunch), a sorter and an interpreter.

Transmitting stations (DATA-PHONE Data sets and card reader or transmitting keypunch) are installed in the ordering-stock maintenance unit of each storeroom organization in the system (figure 1A). Storeroom transactions are transmitted periodically to the Data Center in batches determined by store activity. A normal transmission consists of fixed information (item number) from a master card kept on file and variable information (quantity) keyed in by the operator. Valid transactions include all types currently used in the store record-keeping function, plus "administrative" transactions, to be discussed in a following section.

Data Processing

Transaction cards received in the Data Center are processed on the IBM 7080 Computer. Processing is usually performed on a weekly basis but may be done daily. This "control" portion of the program verifies that transactions are valid, updates a master tape and provides the storeroom with a list of all transactions received (figure 2). Where transactions are found to be invalid (for example, a receival against an order which has been previously recorded as filled), the transaction is listed with an error code for correction by the store. Once a week the updated master is run through the "Report" portion of the program, which reviews the status of each item and provides:

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ITEM	TRAN. TYPE	SER. NC.	ERRCR CCDE	QUAN.	CRG.-CCDE	CRC.NC.	DEL. NC.	CRC. TYPE	DEL. WEEK
54C4C2	23	311C01		97.		7	0		
54C4C2	30	311C56		97.	22412				
543535	28	311134		154.	18000				
546176	23	311C49		332.		319CC	0		
546176	23	311C5C	203	1892.		63034	0		
546176	30	311C57	216	2224.	22414				
546378	23	311230		34C.		319CC	C		
546440	30	281158	216	11.	22414				
546440	30	281158	216	11.	22414				
546441	22	311C86		2CC.		73CCC	1	1	63101
546441	22	311C87		10C.		73CCC	2	1	63111
546441	22	311C88		2CC.		73CCC	3	1	63121
549171	23	311051		139C.		213CC	C		
549171	23	311C52		1820.		213CC	C		
549171	30	311C58	216	321C.	22414				
561334	23	311328		303.		21	1		
563468	22	311C89		10C.		1	1	1	63091
566118	23	3112CC		385.		2	C		
566618	23	311329		254.		222CC	C		
569075	3C	311126		24C0.	22412				
572771	30	311C79		2.	22331				
573202	23	311201		473.		3	C		
573202	30	311316		288.	22412				
576637	3C	281289		3CCC.	22912				
592146	30	311268		12.	22331				
592169	28	311135		1.	18CCC				
592173	30	271C26	216	4C.	22331				
592196	C	325210	1C4	C.	21C				
592247	22	311142		5C0.		4	1	1	63091
592248	30	311C43		38.	22424				
5925C6	30	311C81		32.	22331				
592506	30	311269		35.	22331				
596425	28	311111	216	1428.	18CCC				
596425	30	311C44		12.	22331				
596425	30	311112		132.	22331				
621864	30	311317		15CCC.	22336				
636393	23	3112C2		51.		121CC	C		
715188	30	311371	216	1COCO.	22912				
715310	23	311155		2513.		1	0		
715310	30	311372		2513.	22912				
715363	23	311156		10164.		4	0		
715363	30	311373		5808.	22912				
715363	30	311374		726.	77122				

TRANS. COUNT CPER 0088 ADMIN C0C2 OTHER CC04 TOTAL CC94
HIGH SER.NO.1377 INCLD.ERRORS 0C04 NOT INCLD CCCO

Figure 2. Transaction Listing—Showing Transactions Processed in Week.

STCRE NC. 155 GA-J RAW MATL CEPT 2259-2 -CPEN CRCERS- WEEK NC. 31 63C81

ITEM NC.	CRDER NC.	CRC. DATE	CEL. NC.	CUAN. CRC.	BALANCE CUE	CEL. DATE
315562	313CC	63C41	1	15C.	C.	63C81
			2	15C.	15C.	63C91
315562	73CCC	63C71	1	2CC.	2CC.	63101
			2	2CC.	2CC.	63111
			3	2CC.	2CC.	63121
316556	5	63C43	1	4CC.	4CC.	63071
316556	617CC	63C64	1	1CC.	1CC.	631C1
326983	31300	63C33	1	1CC.	58.	63091
326983	618CC	63064	1	1CC.	1CC.	63101
			2	1CC.	1CC.	63111
			3	1CC.	1CC.	63121
326986	313CC	63C33	1	3CC.	C.	63C61
			2	3CC.	C.	63C81
			3	4C0.	4CC.	63C91
327012	31300	63C33	1	14C0.	C.	63C51
			2	18CC.	C.	63C61
			3	7CC.	C.	63C71
			4	14C0.	1356.	63C91
			5	18CC.	18CC.	63C91

Figure 3. Open Order Listing—Showing Current Status of Orders Placed on Suppliers and Feeder Shops.

(1) an *Item Status* report (figure 4)—listing stock on hand, investment, weeks of stock, cumulative usage, average demand and status during a future interval. Future status is determined by comparing the quantity (ON HAND + DUE IN — EXPECTED DEMAND) against a preset low limit over an interval of weeks determined by the storeroom.

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ITEM NC.	CL. NC.	CCST PER C	$ INVESTMENT CURR.	CHGE.	CUM. USAGE	CN HAND	QUANTITY IN	CUT	WKS. STK.	EVAL. CCDE	AVG. DEMAND	FUT.CN HAND	RUNOUT WK.	ACTION
536908	3	48.CC	1223.	474.	7582.	2547.	1127.	139.	45.6	15083	56.	3180.		
536935	3	50.60	26.	C.	79.	52.	0.	C.	18.5	15083	3.	21.	42	*R 36
537013	3	52.5C	235.	C.	416.	448.	0.	0.	35.7	15C83	13.	260.		
537014	3	53.8C	84.	C.	655.	157.	0.	0.	9.4	15083	17.	124.	33	PU 40
537487	3	55.1C	93.	C.	0.	168.	0.	C.		15083	0.	168.		
537533	3	47.1C	843.	-819.	28565.	179C.	0.	1738.	2.3	15C83	786.	1004.	32	*RP 10200
537754	3	49.7C	1243.	C.	3896.	2500.	C.	C.		15083	0.	3000.		
537766	3	50.3C	670.	-94.	134C.	1332.	0.	186.	152.6	15C83	9.	1201.		
5381C2	3	49.40	126.	C.	95.	255.	0.	C.		15083	0.	255.		
538288	3	52.5C	151.	C.	73.	287.	0.	0.	65.8	15083	4.	222.		
538626	3	61.3C	31.	C.	41.	50.	0.	0.		15083	0.	50.		
539301	3	48.60	535.	C.	2251.	11CC.	0.	C.	48.5	15083	23.	762.		
539303	3	48.40	441.	C.	C.	911.	0.	C.		15083	0.	911.		
539307	3	48.20	463.	C.	1848.	960.	C.	C.	13.7	15083	70.	540.	37	R 900
539344	3	47.1C	654.	C.	15C2.	1389.	0.	C.	23.9	15083	58.	516.		
539419	3	50.8C	1473.	231.	2218.	2899.	455.	C.	164.4	15083	18.	2972.		
539423	3	54.7C	0.	C.	647.	0.	0.	C.	0.0	15083	32.	-32.	32	RP [illegible]
539426	3	50.3C	622.	5C.	1327.	1237.	1C0.	C.	132.1	15C83	9.	1097.		
539437	3	48.90	374.	C.	57C.	765.	0.	C.	107.9	15083	7.	559.		
539438	3	49.00	282.	C.	191.	575.	0.	C.	52.7	15083	11.	411.		
539440	3	49.00	35.	C.	0.	72.	0.	0.		15083	0.	72.		
539442	3	51.40	146.	C.	392.	284.	0.	C.		15083	0.	284.		
539444	3	52.40	0.	C.	1253.	C.	0.	C.		15083	0.	0.		
539447	3	47.7C	6130.	1885.	30263.	12851.	3951.	C.	8.9	15083	1448.	11403.	32	*PU 4C
539449	3	47.9C	341.	C.	13C.	754.	[illegible]	C.	53.3	15083	12.	427.		

Figure 4. Item Status Report—Showing Week End Stock Condition and Suggested Action.

This interval is usually procurement time plus a safety factor. This report can be issued, as requested by the store, either on all items or on an "exception" basis (only on items with questionable status). When status is questionable either an order quantity or the pulling up of a delivery date of an existing order is recommended.

(2) an *Open-Order* report (figure 3)—listing each order for replenishment of stock, and showing order number, date order was placed, order quantity, balance left to be delivered and scheduled delivery dates. This can also be on an exception basis, tying in with the Item Status Report.

(3) a *Store Summary* (figure 5)—listing for each class of items or material and for the store in total, the average and current investment and change since previous weeks, cumulative current and

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CLASS	NC. ITEMS	$ INVESTMENT AVG.	CURRENT	CHANGE	$ USAGE CURRENT	AVG.	$ EXP. DEMAND	$ CN CRDER	WKS. STCCK	CCST INDEX
1	22.	19599.	15435.	-3541.	3594.	1587.	1C11.	15902.	15.3	
2	32.	25C32.	22678.	-3556.	5124.	4316.	3442.	63319.	6.2	
3	54.	9C854.	101740.	8571.	5441.	4879.	5C31.	63271.	20.2	
6	1.	462.	462.	C.	0.	27.	24.	0.	19.2	
7	9.	2956.	2939.	-5.	5.	38.	62.	225.	47.3	
8	63.	26914.	27165.	-2258.	4430.	1575.	2139.	26357.	12.4	
9	13.	3715.	5242.	-27.	27.	274.	259.	4052.	13.5	
10	6.	1C64.	1473.	231.	C.	57.	79.	315.	18.7	
TCTAL	246.	170598.	177134.	-1CC9.	18629.	13152.	12315.	175961.	14.4	

TCTAL $ 17622. IN 18629. CUT 2. ADJ

Figure 5. Store Summary—Showing Week End Store Condition and Investment Position.

average dollar usage, weeks of stock, and dollar total on order. A "cost index," defined as the dollar cost in ordering and investment changes per $100 of annual usage, can also be printed.

SYSTEM OPERATION

A prime requirement in designing the system was ease of installation. The impact of the new system on the people actually operating the stores had to be considered. A change in mechanical methods such as the use of DATA-PHONE, and reliance on transmission and computer accuracy, was a sufficient load to absorb at one time. No attempt was made to sell or install automatic control concepts such as exponentially smoothed forecasting, mathematically derived reorder points or quantities, changes in ordering intervals or policies, and so on. Control of the system and consequently of investment had been left wholly in the hands of the store. Every effort was made to adjust the system to fit standard operating procedures, particularly where they were governed by accounting or auditing practices.

Options are provided in the system such that the store can designate:

- — use of an Economic Order Quantity (Camp Formula) or a specific number of weeks stock on reordering;
- — use of one of several forecasting procedures based on past usage, or the use of firm short-term advance requirements when available;
- — use of "exception" or complete reporting;
- — preposting of advance "selects" or actual in-out posting.

The store is able to change control criteria on any item at any time. "Administrative" transaction formats are provided so that the store may change the forecasting or ordering options (above), the safety stock level, procurement or ordering interval, or may directly adjust forecasted demand on an arbitrary basis.

The system thus provides, in effect, for both manual and automatic decision-making. The item status evaluation procedure will recommend action to be taken on an item, dependent on criteria furnished by the store. On review the store may or may not find the recommendation accurate. Criteria are adjusted until the recommended and the actual action taken correspond most of the time. At this point adjustment is discontinued and item evaluation is left on an automatic basis.

Administrative transaction codes which will transfer items between stores, cancel an item from a stock list, change item costs or descriptions, make corrections to erroneous prior transactions or correct the balance directly, are also provided. An inventory verification transaction is provided to permit periodic audits (physical count) to be entered. This procedure conforms to standard accounting control practice and automatically reports on system accuracy each month.

All transactions are transmitted to the Data Center where they are batched for processing by the computer. No editing is required in the center, which acts as a collection agency, enters new items, and changes store parameters or operating policies. The Data Center also provides transmission master cards, disseminates the computer-generated reports and maintains a central file of reports.

The previous method of operation was based on continual perusal by stock maintenance clerks of updated individual item ledger cards. The computer-generated reports replace the ledger cards and permit one clerk to handle twice as many items as before. Under the new system, although the clerk's job remains substantially the same, the supervisor is able to more effectively monitor the clerk's judgment and maintain a much firmer control on investment.

DATA TRANSMISSION

Flexibility was the main consideration in the design of the transmission system. The telephone network servicing Kearny compares in magnitude with that of a small city. Development of DATA-PHONE Data Sets by the Distribution Data Processing organization made it feasible to utilize the existing telephone system as a made-to-order data transmission network. Our end objective was Works-wide integrated manufacturing control, therefore every location and organization had to be considered as a potential future transmitting station. With DATA-PHONE service a new station could be added or an old one moved with minimum cost and effort. It should be borne in mind that our entire approach has been an evolutionary one, with self-supporting gradual change based on developments tailored for general application. The design of a separate cabling system, with the capital investment required and the design accuracy necessary to avoid costly future revisions, would have been crippling from the standpoint of time and economics.

The basic transmitting station consists of a card reader* designed and manufactured by Western Electric with a DATA-PHONE subset. In one store with extremely high activity, a transmitting IBM 026 Keypunch (Encoder), adapted by our Distribution Data Processing organization for compatibility with 401 series DATA-PHONE set, was installed.

Receiving stations consist of an IBM 026 Keypunch equipped with self-checking, with the Western Electric translator and Bell Telephone receiving equipment. A paper tape receiving terminal for increased flexibility is expected to be in trial operation in the near future.

With 14 stores operating in the system at present, activity is in the order of 10,000 to 12,000 transmissions per week. Approximately 4,800 of these are made by Encoder from the Jersey City plant, using cards generated in a prior computer system (equipment order explosion).

COMPUTER SYSTEM

The two major programs discussed above were programmed in FORTRAN for the IBM 705. During the development phase, considerable adjustment was made in machine language. The system now operates through INTERPRET 580 on the IBM 7080, with 1401 periphery support on input and output. A modified 1401 card-to-tape program provides an initial screen for invalid and rejected transmissions. The first phase of the 7080 system provides a more thorough check for improper or invalid store transactions.

Figure 6 diagrams system operation. The master balance tapes indicated contain a 3180-character record for each stock item, providing considerable unassigned space for potential future additions to the system. Much of the information on the master is maintained for research purposes. For example, exponentially-smoothed forecasts are developed on each item, although the procedure has not as yet been released for application by the stores. The output transaction tape is used for research output (in 80-column card images) as well as for discrepancies.

Main processing time on the 7080 is approximately 2 hours per week for the 10,000 items currently in the system. In addition, a supplementary transaction analysis is run on the 7080 once a quarter, summarizing and consoli-

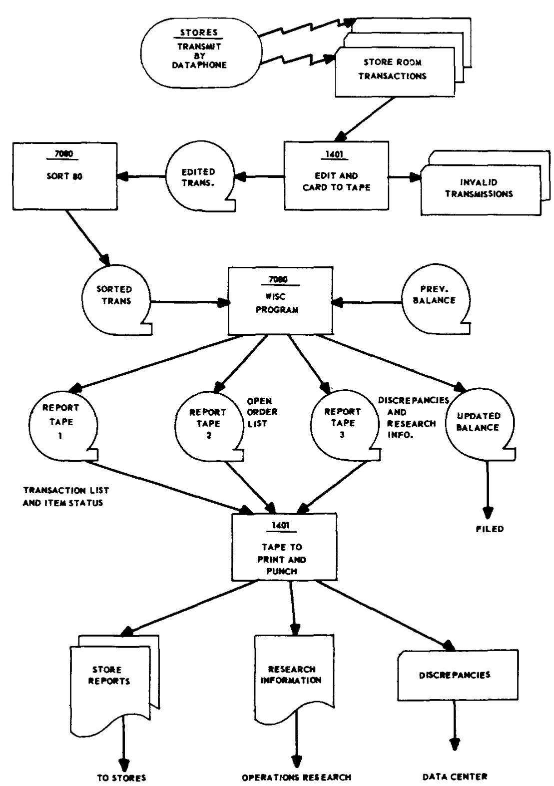

Figure 6. Flow Diagram of Stock Control Data Processing System.

*The IBM 1001 transmission terminal is similar to and based on this reader.

dating for storage all transactions by store in the preceding three months.

EXTENSIONS AND REFINEMENTS

As indicated earlier, our objective is a completely integrated manufacturing control system for the Kearny Works. The stock control system described in this paper is only a part of the work being done towards this objective. Our Computer Methods Development organization has made considerable progress toward completion of a generalized Equipment Ordering system. This system is now operating in 7 major equipment shops and has been linked to the stock control system in one of these. Additional links, such as the placing of orders on a stock store for component apparatus, parts or raw material in tape or card form compatible with stock control formats, are to be made in the near future. Improved stock control system accuracy and effectiveness, and reduced manual effort in transmission will result.

Entry into the Production Control area is keyed to output of both the Equipment Ordering and Stock Control systems. Shop output requirements (production control input) are defined by both non-stock orders generated and placed directly on the shop by the Ordering system, and by orders placed by the store for stock replenishment. Before this area is clear for full development, the Stock Control system must be refined to generate effective order quantities. In current operation, order quantities generated by the system and those finally used are still determined by store personnel, using traditional judgments and rule-of-thumb methods.

It was mentioned earlier that a basic reason for development of the system was to facilitate ordering model construction. With the system developed and operating we are now in a position to do this. The computer programs involved are designed so that we can, for example, draw off each week from the operating system, results for a sample of items. These results can be used to characterize demand patterns and determine delivery variability, determine and evaluate forecasting procedures, and establish reorder points and shortage probabilities. The model based upon this analysis can then be evaluated using the actual operating data under simulated alternative operating conditions.

Initial results on stock parts made in a feeder shop will be course reflect a sub-optimum. However, as we get further along in production control, this will be corrected. Most important is that an almost complete record of actual performance will be available, and can be used to accurately evaluate and prove in any changes proposed in store operating policies, when compared to results derived from parallel operations.

In addition to the main line for development, equipment ordering, stock and production control, attention can now be given to extending the system into subsidiary areas and to refinements in the existing system. Future developments of this type include:

— automatic generation of purchase order details and paper work. This should incorporate generation of feedback cards for receivals and the possible inclusion of major suppliers, other Works and the Purchasing organization in the DATA-PHONE service network.

— transmission of required information from the source, thus reducing or eliminating current paper work routines and procedures.

— improvement of existing hardware to eliminate the necessity for batch transmission, thus reducing card handling at the receiving end and providing a linkage to future decentralized shop production control systems.

CONCLUDING REMARKS

There are many facets to the continuing revolution in data processing which has been taking place over the past ten years. Increased speed of processing in itself caused significant changes. The flexibility afforded by the manipulative characteristics of the stored program speeded further change. But the increased use of decision-making mathematics, together with improved input-output links, is primarily responsible for the acceleration in pace now becoming evident.

EDP systems can be roughly divided into two categories: (1) systems designed to speed the flow of information or process data more economically and (2) systems to facilitate or eliminate management decision-making. Development has proceeded to date largely in applications of the first type. Early conversion of EAM applications in payroll, billing and general accounting fall wholly in this category, as do a great number of control systems. Decision-making in this category is primarily a matter of following a short series of known rules which automatically determine, and in control systems execute, a course of action. For complete systems integration of an operating enterprise it is necessary to incorporate systems of the second category. Development in this area in general is just beginning.

It is true that in process industries and military applications, progress in decision-making has been rapid. But these areas are, generally speaking, in one case functionally not complex, in the second as applications to new processes rather than changes to existing structures. Too, in a large number of businesses, information systems are sufficient for almost all needs. Significant decision-making is conducted largely at executive levels and need not be incorporated in day-to-day operating procedures. In companies of any significant size in the manufacturing industries this is not usually the case, and the distinction between the two types of systems becomes pertinent.

Development of non-decision-making systems in manufacturing has been the rule to date, due primarily to the fact that savings in this area are normally measurable beforehand and can be readily realized. However, the practical limit to applications of this type is being reached by users who have been in the field for any appreciable length of time. It must be recognized, for continued effective development, that this limit marks a turning point. A change in outlook is required as development begins in the decision-making areas of production control. Systems people will be working directly in the heart of manufacturing activity, examining decision-making processes now performed by production management and engineering. Input data to this point has frequently been in the form of punched cards prepared for previously existing EAM procedures, or was prepared in a similar manner. In production areas, much of the data required for effective decision-making must be initiated directly at the production machines or transmitted from the production floor. The background language to this point was largely that of billing, wages, taxes, bill of materials and sourcing. In production areas, the programmer-analyst will be concerned with manufacturing layouts, process characteristics and limitations, machine or tool types and functions, production and quality requirements. What all this means is that some reorientation is required to establish clearly the direction for progress towards long-term objectives. Systems have till now usually been independent and isolated from each other. Future development will result in a common interface through which these isolated areas will be linked. Input-output links must be compatible, but existing work on the subsidiary functions should not determine their basic forms. Basic production needs must override if the eventual system is to be sound. The automatic factory will be operated under a completely integrated manufacturing control system. We would hesitate to say that this degree of automation can be achieved in a manufacturing complex such as the Kearny Works. But we would be equally hesitant to say that it could not.